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## ABSTRACT

Preservice elementary school teachers entering a science methods course have been found to differ widely in their command of science process skills. A study was undertaken to examine several variables suggested by the literature to be related to these skills. Forty-five preservice elementary school teachers (5 males and 40 females) were tested at the beginning of their science methods courses to determine their science process skills, field dependence-independence, dogmatism, propositional logic ability, background in science, and age. The data indicate that field-independent and open-minded individuals have significantly better command of process skills than do their more field-dependent and closed-minded counterparts, and that propositional logic ability and science background are not as strongly related to process skills as are the two cognitive styles. This study supports the assertion that certain cognitive makeups are associated with ability in science, and perhaps, reflects that the type of science to which most elementary science teachers are exposed does little to prepare them to understand or teach how science works. (Author/JN)

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FACTORS RELATED TO PRESERVICE ELEMENTARY  
SCHOOL TEACHERS' SCIENCE PROCESS SKILLS

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Factors Related to Preservice Elementary  
School Teachers' Science Process Skills

Introduction

Preservice elementary school teachers entering a science methods course can be expected to differ widely in their command of science process skills. This statement represents an empirical observation of the performance of several classes of preservice teachers on the SAPA pretest for teachers at both Rutgers University and the University of Utah, and is verified by the students' subsequent performance in classroom activities. Scattered throughout the literature one can find references to a variety of variables that seem to be related to subjects' science process skill or science achievement and ability in general. In the interest of substantiating some of these relationships and of determining their relative strength, the study described below was undertaken.

The variables investigated in the study included field dependence-independence, dogmatism, propositional logic ability, amount of science background, and age. A connection between ability and performance in science and field dependence-independence has been suggested by a number of studies (Witkin et al., 1975, Bowles and Boss, 1974, and Shymansky and Yore, 1980). Strawitz (1975) and Bird (1970) found dogmatism to be related to attitudes toward science, which, in turn, are believed to be related to performance in science. In addition, dogmatism has been shown to be related to propositional logic ability (Ross and Fletcher, 1974), another variable in this study. Propositional logic ability has been shown to be related to achievement in science (Lawson et al., 1975, and Enyeart et al., 1980). That science process skills are related to the amount of science studied is suggested by Gabel et al. (1977) and Gabel and Rubba (1980) and is intuitively reasonable in addition. Since age varied widely among the subjects, and since it is possible

that process skills diminish with disuse, age was included as a variable in the investigation.

### The Study

The study consisted of testing the subjects at the beginning of their science methods courses at the two institutions mentioned above. Correlational analysis and multiple regression analysis were used to interpret the data. Science process skills were assessed using the SAPA Science Process Measure for Teachers (SAPA), a measure routinely administered to students beginning these methods courses to determine their familiarity with some of the SAPA process skills. Field dependence-independence (FDI) was determined by using the Embedded Figures Test (EFT), on which a low score indicates field independence. Dogmatism was measured by Rokeach's Dogmatism Scale, on which a low score indicates open-mindedness. Propositional logic ability (PLA) was measured by use of the Propositional Logic Test (PLT), a locally developed, validated measure of this ability, on which a high score indicates high ability. Total background in science was volunteered by the subjects and included the sum of the number of high school courses and college courses taken. Age was also volunteered by the subjects.

The sample consisted of 45 preservice teachers, including 5 males and 40 females, all of whom intended to become elementary school teachers. Their ages ranged from 19 to 45 years, with a mean of 27 and a standard deviation of 8.

### Findings

Pearson correlation coefficients between each of the variables were calculated and are reproduced in Table 1. These data clearly indicate that science process skills are related to each of the variables investigated with the exception of age. It appears that for this sample, subjects did not lose (or gain) in their process skills simply by aging. The negative coefficients

Table 1: Pearson Correlations Among Variables

|        | FDI    | PLA    | DOG    | TOTSCI | AGE   |
|--------|--------|--------|--------|--------|-------|
| SAPA   | -.48** | .49*   | -.37** | .31*   | .03   |
| FDI    |        | -.46** | .03    | .12    | .20   |
| PLA    |        |        | -.23   | .32*   | .01   |
| DOG    |        |        |        | .19    | .29   |
| TOTSCI |        |        |        |        | .44** |

\*\* $p < 0.05$ , \*\*\* $p < 0.01$

for the relationships between SAPA and FDI means that more field independent subjects were better equipped with process skills than their field dependent counterparts. Likewise, the negative coefficient for the SAPA and DOG relationship indicates that the more open-minded subjects had the better process skills. Good process skills were also associated with good propositional logic ability and greater exposure to science courses.

While interesting, Pearson correlations tell little about the independent strength of the relationship of each of the independent variables to the dependent variable, since each is also correlated to the others to some extent. In order to take a more meaningful look at the relationships indicated above, the technique of multiple regression analysis was employed. Since age was not related to process skills, it was not included in the subsequent analyses.

Multiple regression analysis allows the investigator to control the contribution to the variance in the dependent variable that the independent variable of interest shares with the other independent variables. Thus, significant relationships of a "purer" nature can be identified between

variables. Furthermore, the technique can provide an assessment of the amount of variance in the dependent variable independently contributed by each of the independent variables.

Table 2 indicates the standardized regression coefficients for and the proportion of the variance ( $R^2$ ) in the SAPA variable contributed by each of the independent variables when the variance in SAPA attributable to the other independent variables is controlled.

Table 2: Standardized Regression Coefficients and  
Independent  $R^2$  Contributions for the  
Regression of SAPA on Independent Variables

|        | Beta | $R^2$ | F(df=1,40) |
|--------|------|-------|------------|
| FDI    | -.35 | .10   | 6.8*       |
| PLT    | .23  | .03   | 2.3        |
| DOG    | -.29 | .08   | 5.3*       |
| TOTSCI | .14  | .02   | 1.2        |

\*= $p < 0.05$

These data indicate that both FDI and DOG significantly contribute to the variance in science process scores, even after the variance in SAPA that they share with the other independent variables is controlled.

When a standard regression of SAPA on both FDI and DOG is run, the two variables are able to account for a significant ( $F=11.7$ ,  $df=2,42$ ) 36 percent of the total variance in SAPA. The summary table for this regression is reproduced in Table 3.

Table 3: Summary Table for the Regression  
of SAPA on FDI and DOG

|     | Multiple<br>R | R <sup>2</sup> | R <sup>2</sup><br>Change | Simple<br>R | Beta | F      | df   |
|-----|---------------|----------------|--------------------------|-------------|------|--------|------|
| FDI | .48           | .23            | .23                      | -.48        | -.47 | 12.8** | 1,43 |
| DOG | .60           | .36            | .13                      | -.37        | -.36 | 8.5**  | 2,42 |

\*\*=P<0.01

When the two remaining independent variables are added to the regression equation, an additional 7 percent of the variance in SAPA is explained, but this is not a significant increase ( $F=2.3$ ,  $df=2,40$ ). The summary table for this regression is reproduced in Table 4.

Table 4: Summary Table for the Regression of  
SAPA on EFT, DOG, PLT, and TOTSCI

|        | Multiple<br>R | R <sup>2</sup> | R <sup>2</sup><br>Change | Simple<br>R | Beta | F    | df   |
|--------|---------------|----------------|--------------------------|-------------|------|------|------|
| FDI    | .48           | .23            | .23                      | -.48        | -.35 | 6.8* | 1,43 |
| DOG    | .60           | .36            | .13                      | -.37        | -.29 | 5.3* | 2,42 |
| PLA    | .64           | .41            | .05                      | .49         | .21  | 2.3  | 3,41 |
| TOTSCI | .65           | .43            | .02                      | .31         | .14  | 1.2  | 4,40 |

\*=P<0.05

#### Conclusions and Implications

The data have from this study have indicated that, as predicted, the degree to which a person is field independent is significantly related to his or her prowess with process skills. Likewise, more open-minded individuals seem

significantly more prepared with respect to process skills than their more closed-minded counterparts.

Propositional logic ability is also related to process skills, but some of this relationship is accounted for by the concomitant relationship between PLA and FDI. Hence, PLA is not as strong a predictor of command of process skills as FDI. Surprisingly, when all three cognitive variables are controlled, the amount of science a person has taken has little to do with his or her command of process skills.

The fact that one can explain over one-third of the variance in the subjects' process skill scores purely on the basis of two cognitive styles without regard to the amount of science studied supports the work of other researchers who have found that certain cognitive makeups are associated with ability in science. It may also reflect, however, that the type of science to which most elementary science teachers are exposed does little to prepare them to understand or teach how science works - they were probably taught science as fact rather than act. It seems likely that more exposure to and training in the processes of science would be beneficial for many prospective elementary school teachers.

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